

# Medical Ceramic Oxygen Generator: An Emerging Method For Generating Oxygen In-Situ

Presentation to Medical Gases Virtual Event:  
Next Level Healthcare, A World Beyond COVID

April 7, 2022

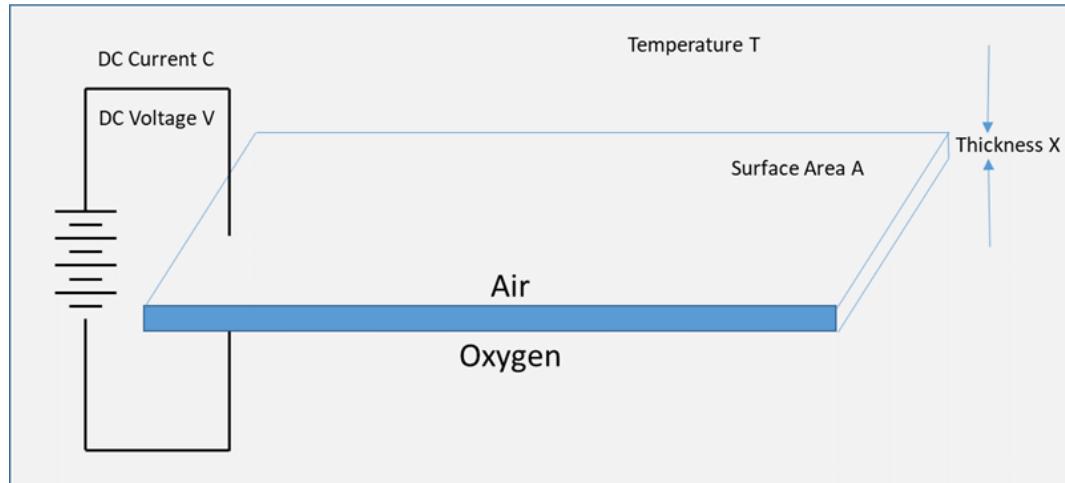
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# Bottom Line Up Front (BLUF)

- NASA is developing & prototyping a new type of oxygen generation system
  - Ceramic ion transport membrane
  - Solid state device: high purity, high pressure, no moving parts, insensitive to humidity
- The initial prototype operates at a small scale (30-40 slpm, 5-10 bar)
  - NASA recognizes that many hospitals need lots of oxygen
- NASA has started the development & prototype of a two-stage system
  - Stage 1 delivers O<sub>2</sub> at 5-10 bar, Stage 2 delivers O<sub>2</sub> at 150-200 bar
  - A small scale system, capable of filling cylinders may address an immediate need for global health
- NASA is searching for partners and collaborators
  - NASA needs a very small system: 3 slpm, 200 bar
  - NASA does not have a charter to build systems for hospitals
  - NASA is interested in partnering with scaling partners and collaborators
- Watch for a NASA Request For Information this summer
  - Plans are to post an RFI to SAM.gov

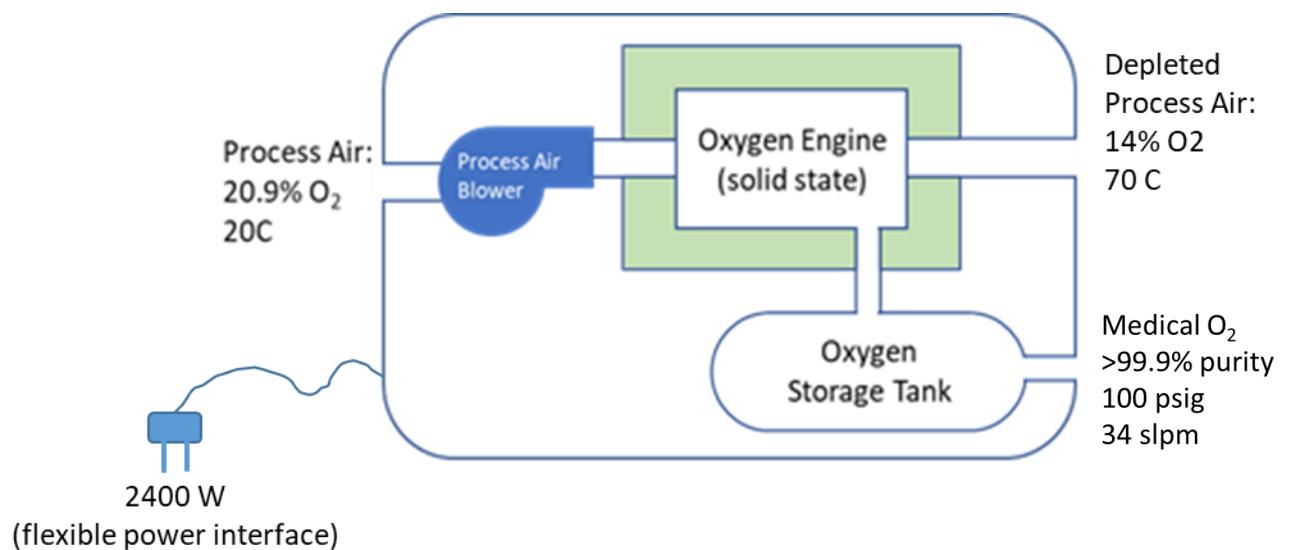
# What is M-COG?

M-COG uses a ceramic ion transport membrane  
Purity is >99.9%, system performance is insensitive to air temperature, atmospheric pressure, relative humidity



Ceramic Oxygen Generators pass oxygen ions through rock. The result: pure O<sub>2</sub>, using a solid state process

This technology was demonstrated >10 years ago but 10 years ago, it was big, slow, power hungry



NASA is developing a new O<sub>2</sub> generator  
The power efficiency and delivery pressure is better than anything before – this can provide immediate benefit to hospitals in remote locations

# What is new about your approach?



This wafer is strong and rugged  
This is unique among COG  
In the past, COG systems have been  
thin and brittle

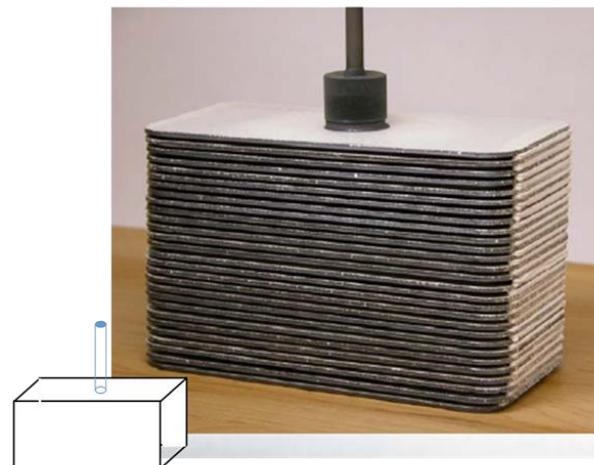
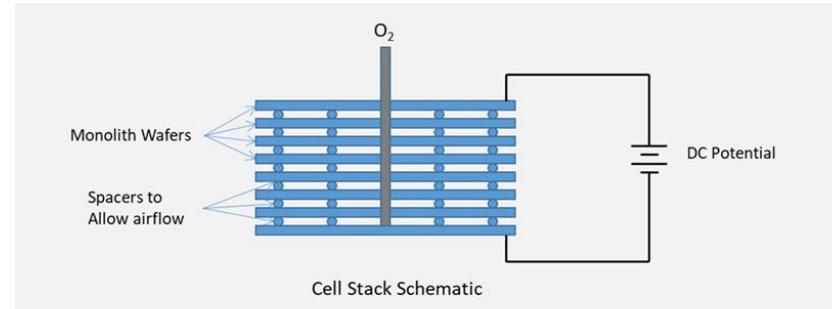


Photo of entire cell stack

Cell Stack Electrical Schematic,  
Photo of cell stack,  
Phot of cell stack cutaway

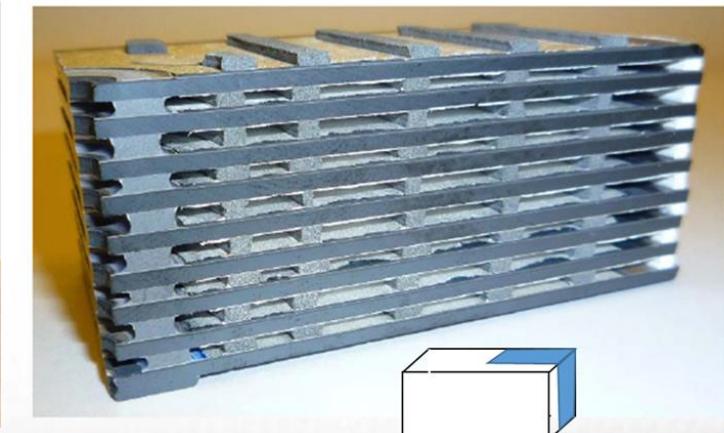
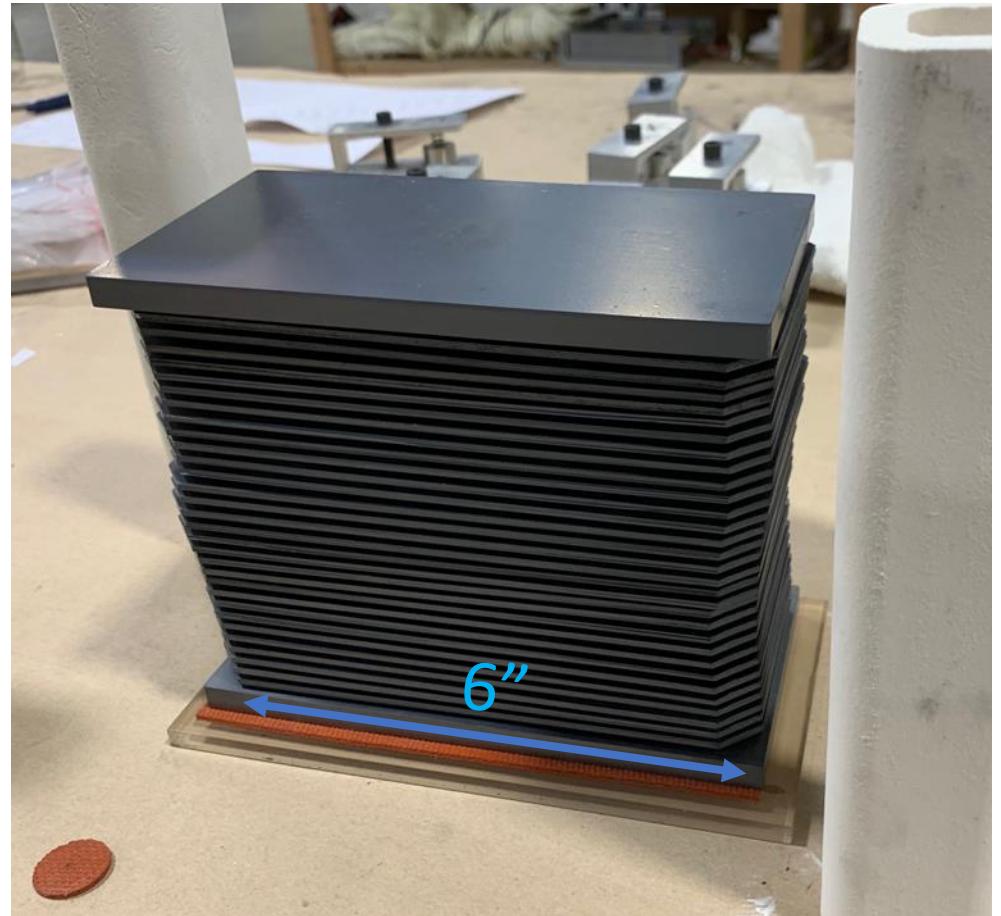
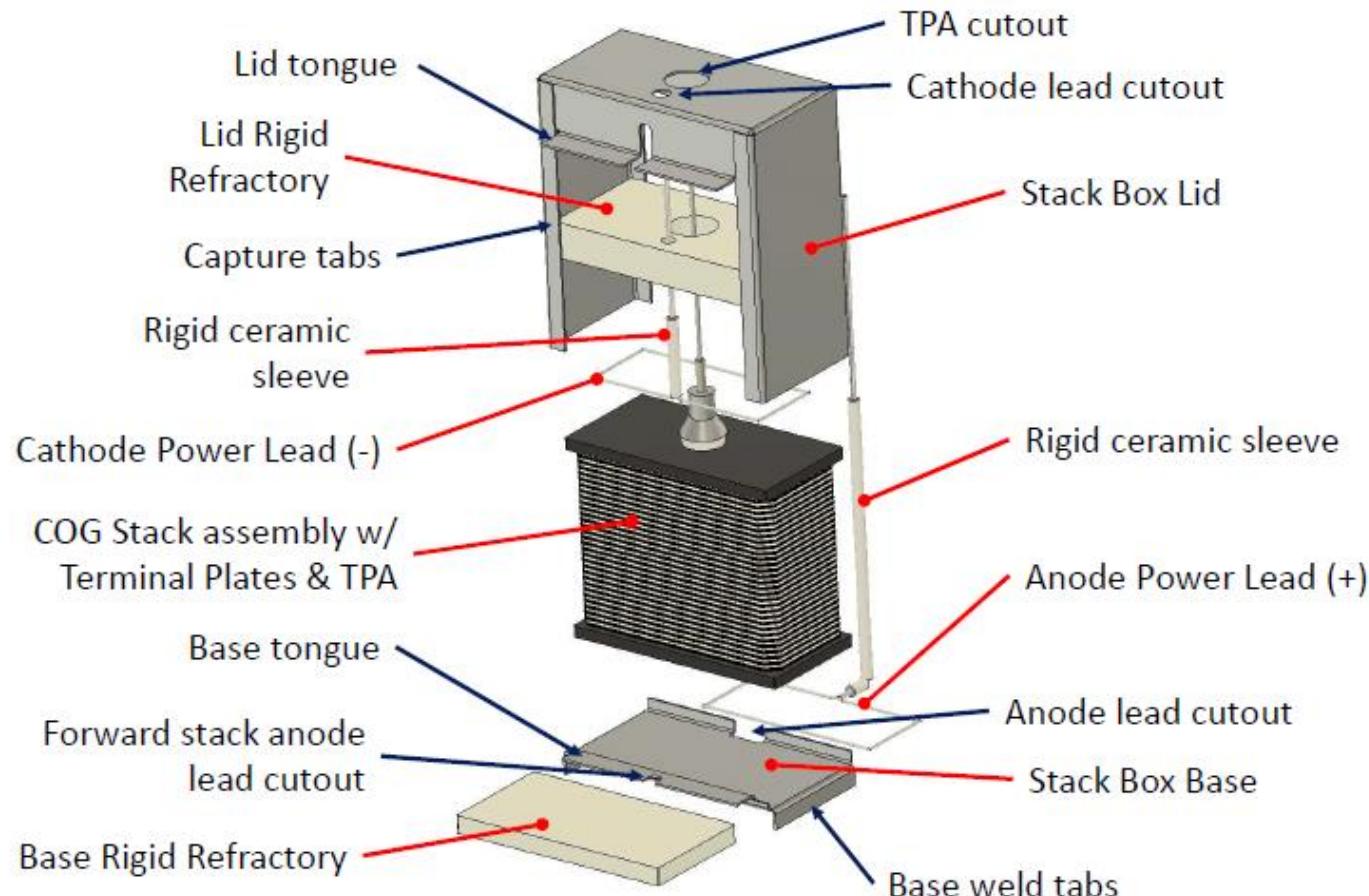


Photo of cutaway  
(shaded section)

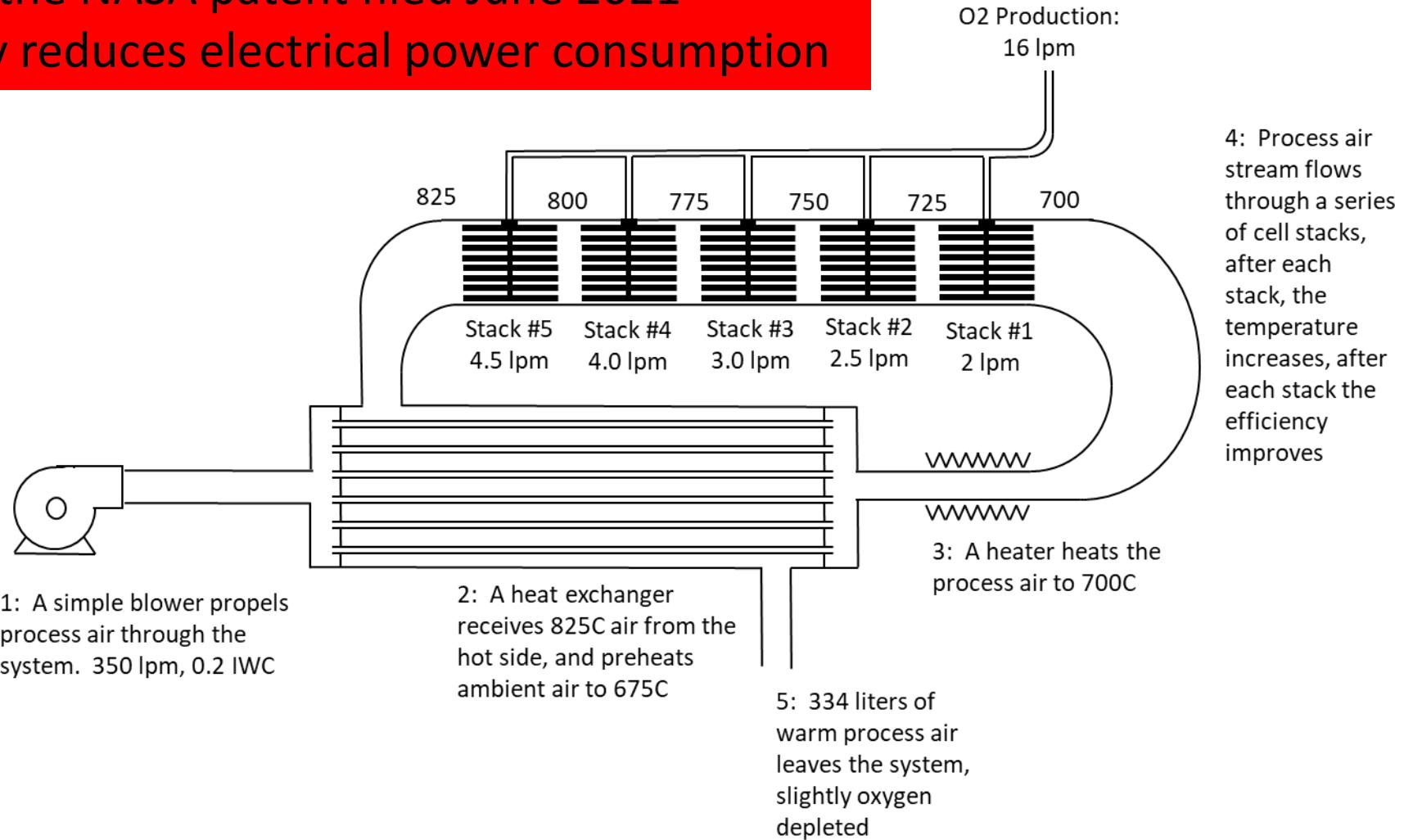
# What is new in your approach?

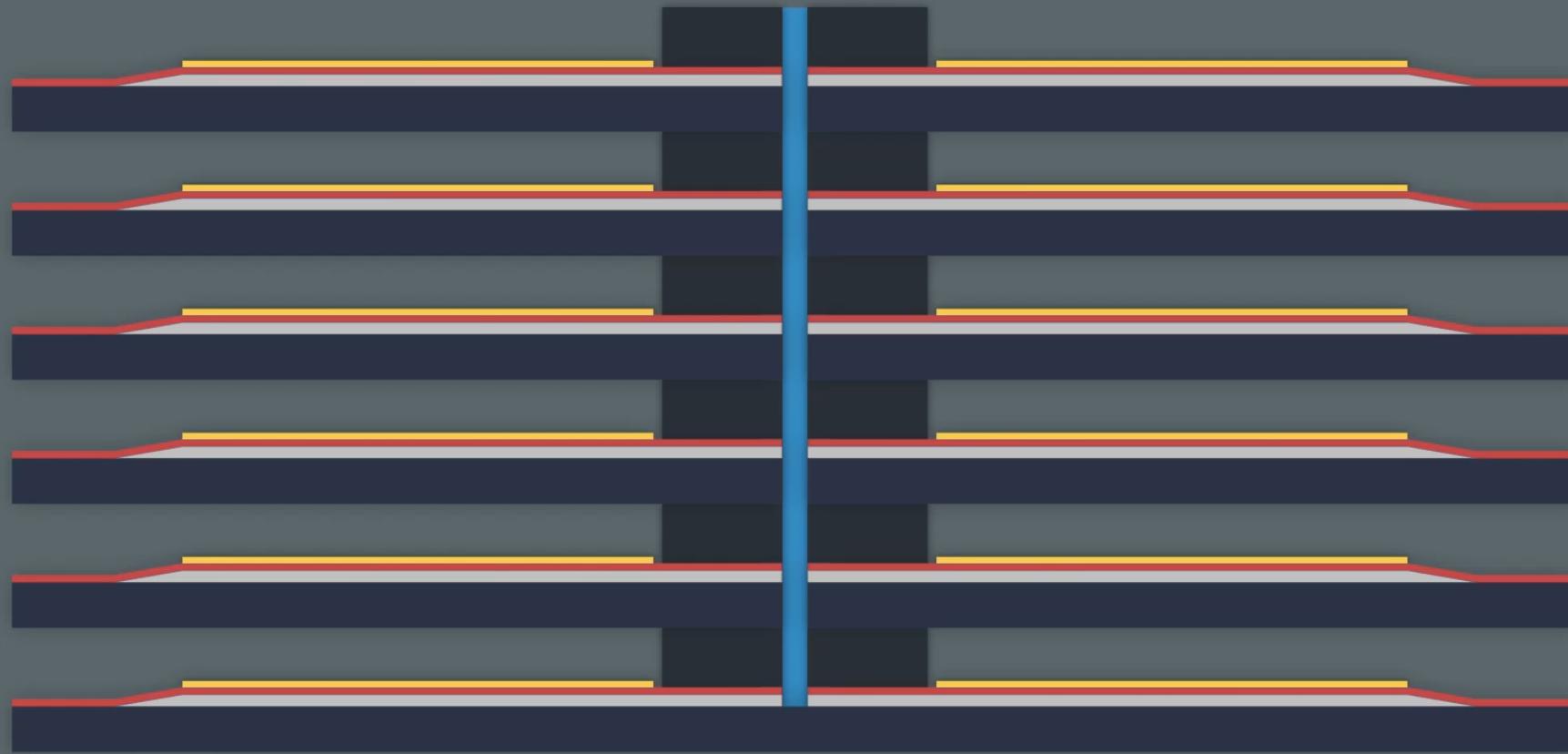


A hospital oxygen generator system would use a series of cell stacks. Larger hospitals would use a system with more cell stacks, smaller hospitals would use a system with fewer cell stacks.

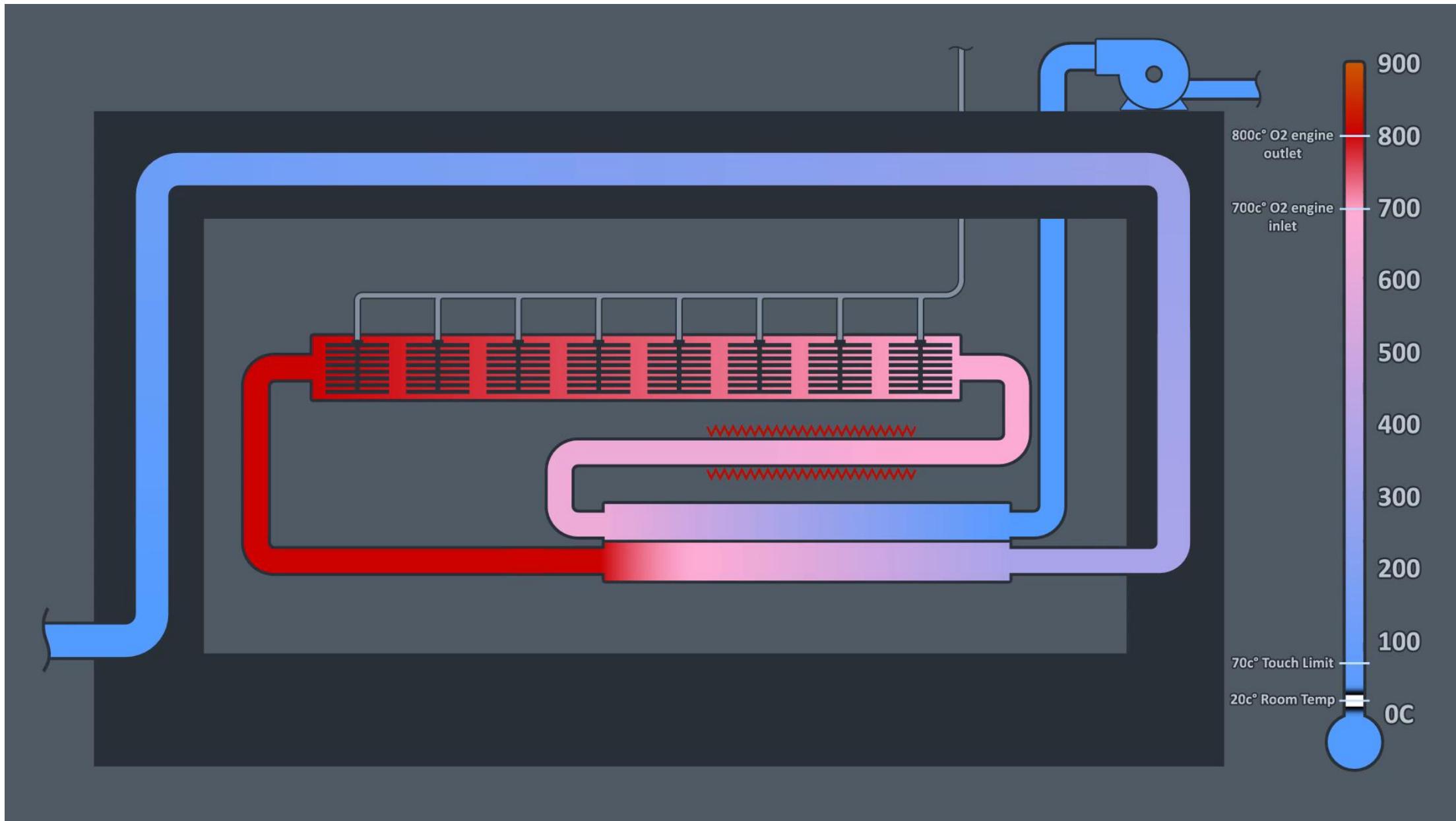
# What is new in your approach?

Figure from the NASA patent filed June 2021  
Substantially reduces electrical power consumption



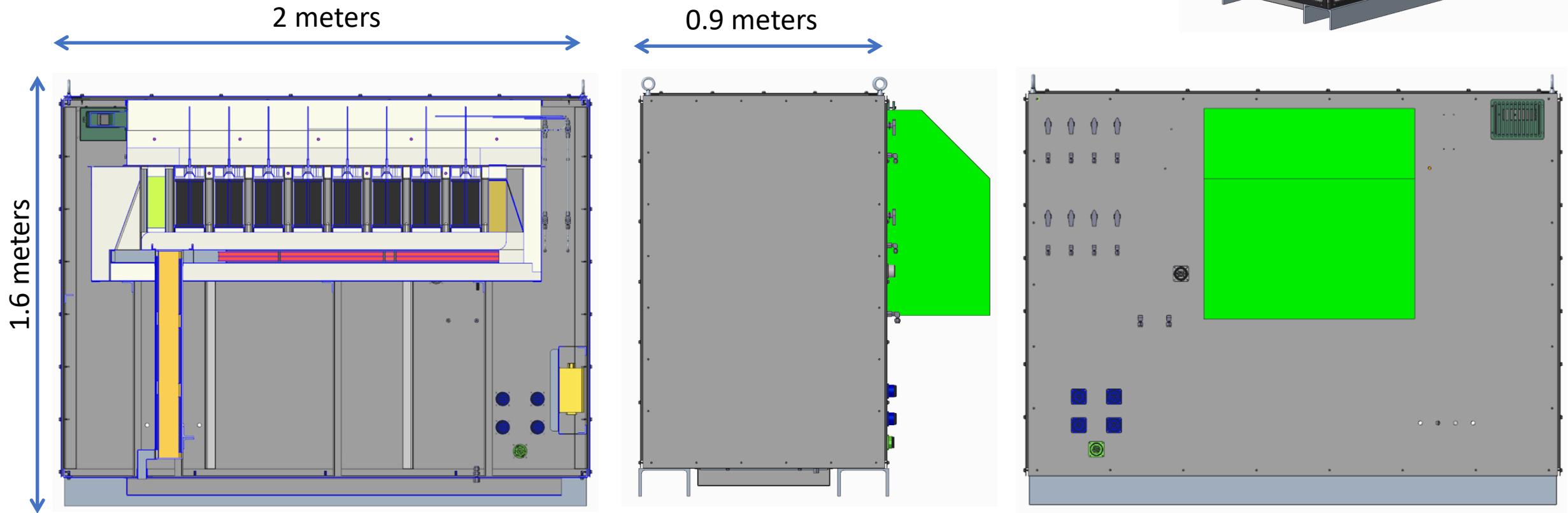


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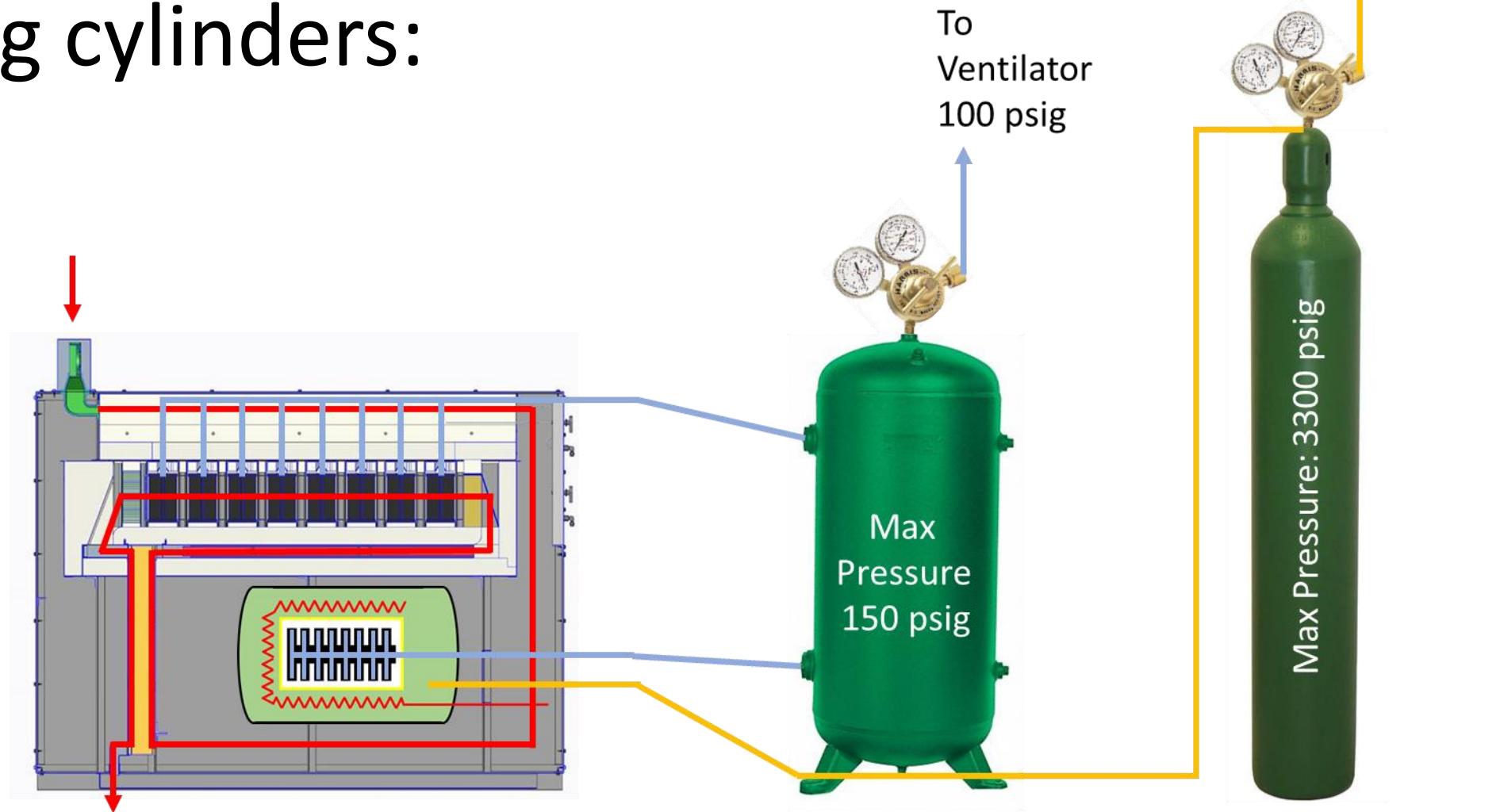


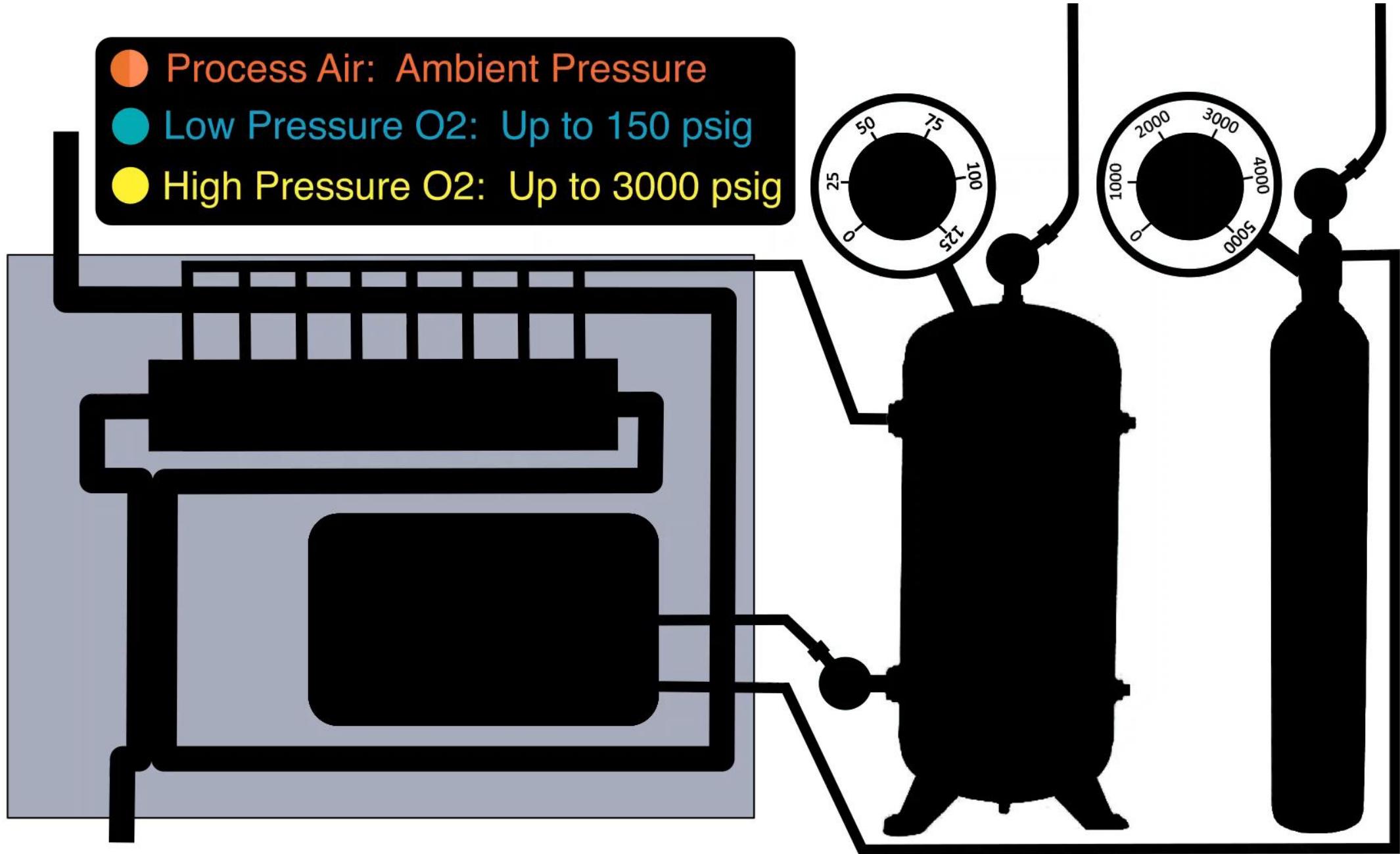
# The initial prototype operates at a small scale:

Delivery Rate: 34 standard liters per minute  
Delivery Pressure: 8 bar

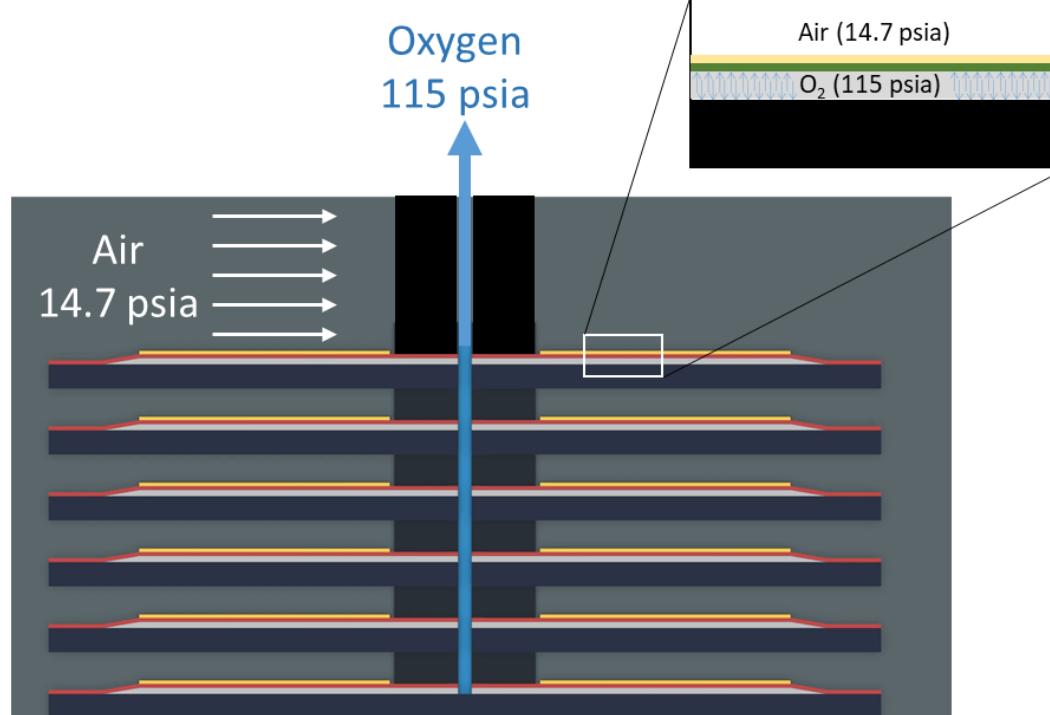


NASA is beginning the development of a 2-stage system, capable of filling cylinders:

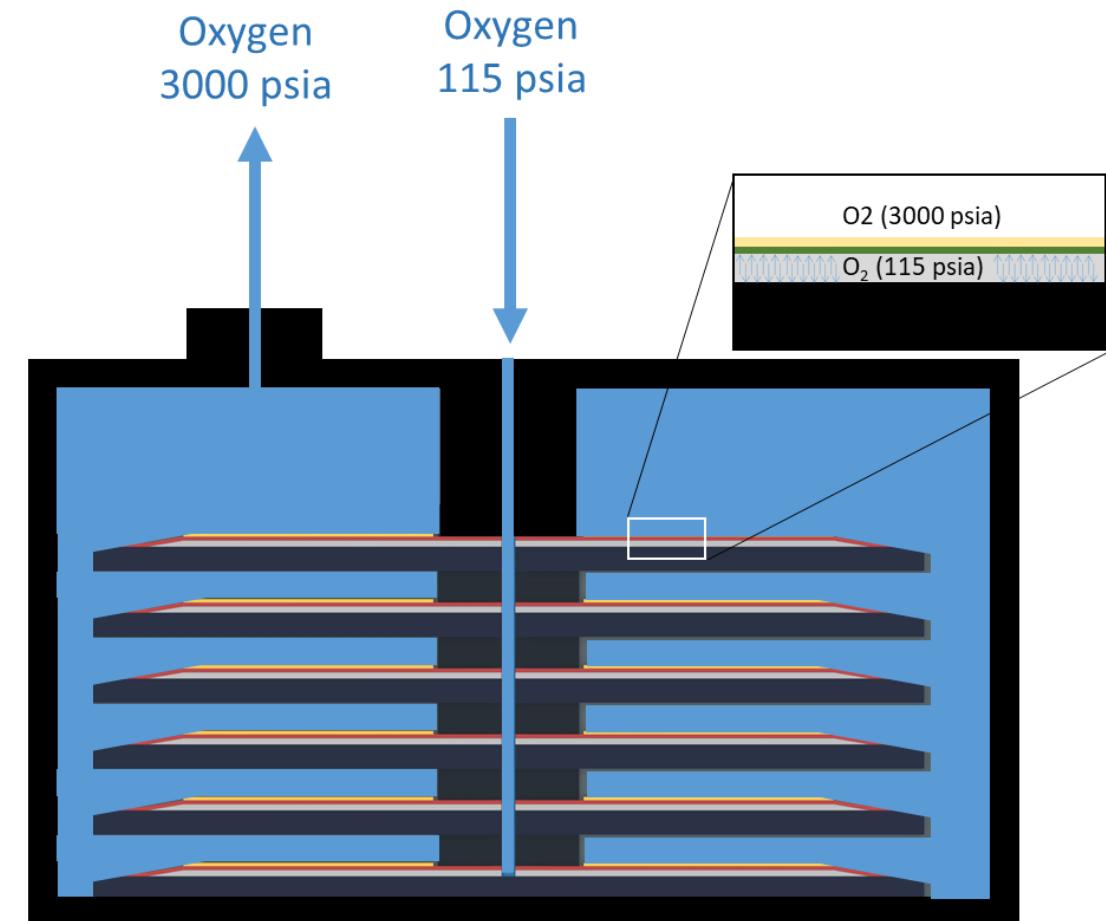




# A Comparison of M-COG Wafers to Bottle Filler Wafers

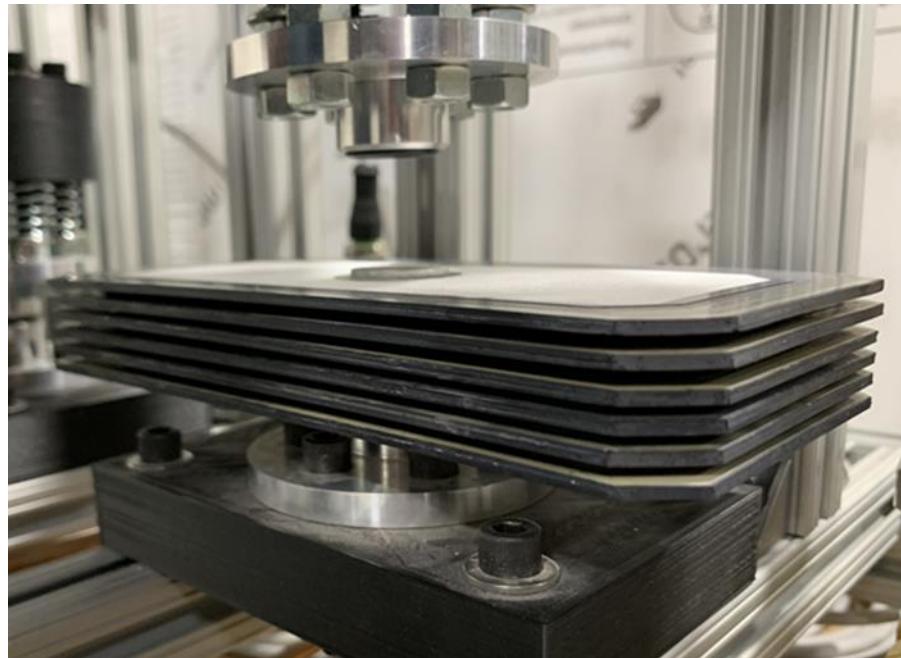
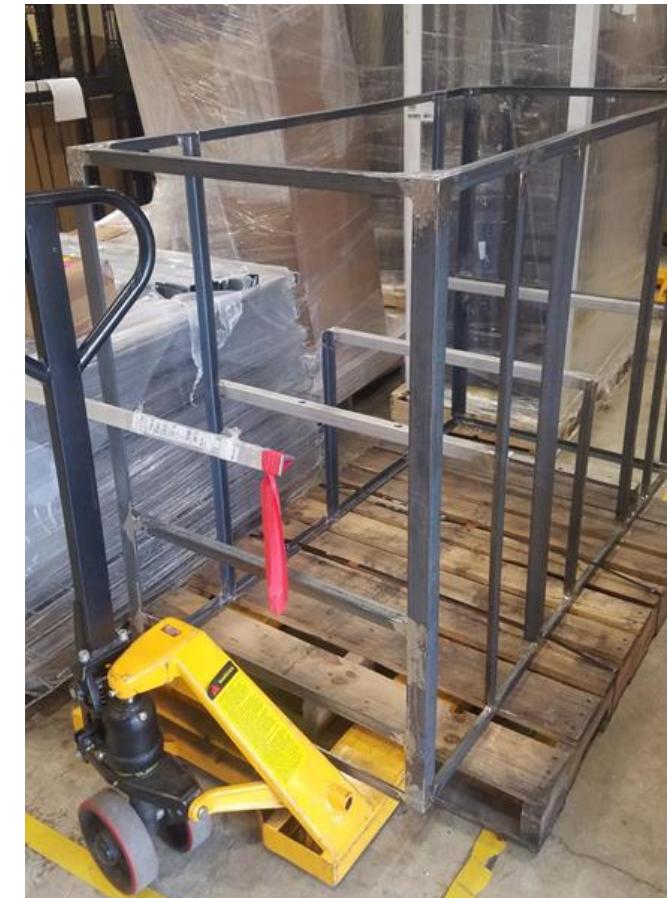


**M-COG Configuration**  
Wafers in slight tension  
Air on outside  
115 psia O<sub>2</sub> on inside



**eCOG-C Configuration  
(ship in a bottle)**  
Wafers in large compression  
3000 psia O<sub>2</sub> on outside  
115 psia O<sub>2</sub> on inside

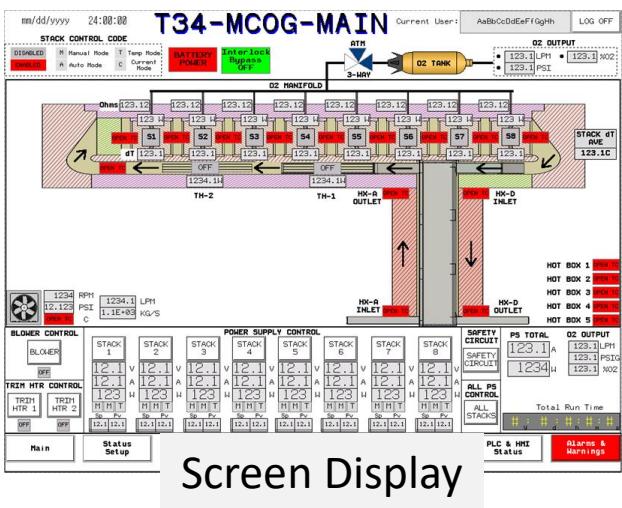
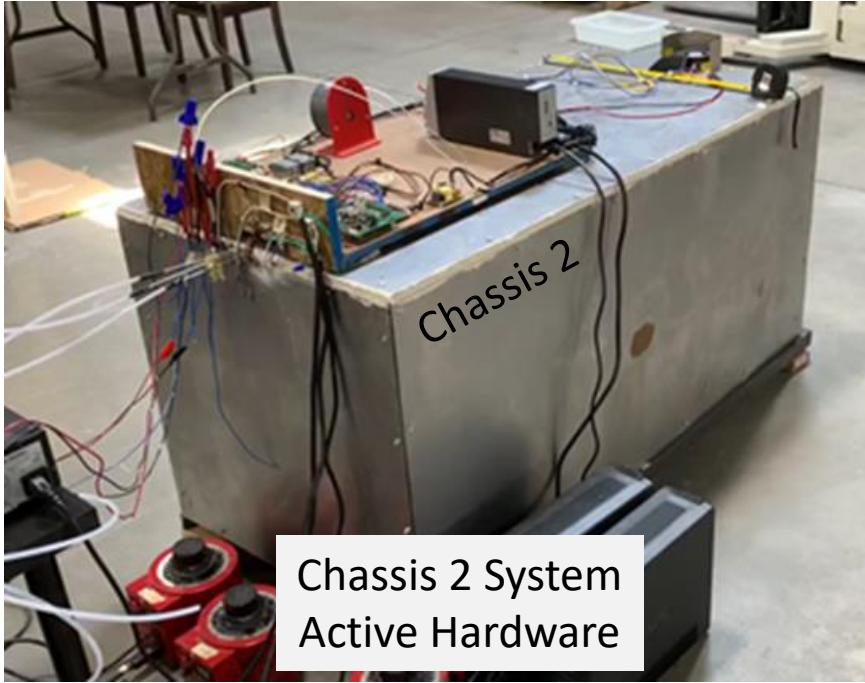
# Current Status: NASA is Literally Building “Chassis 2”



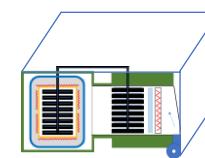
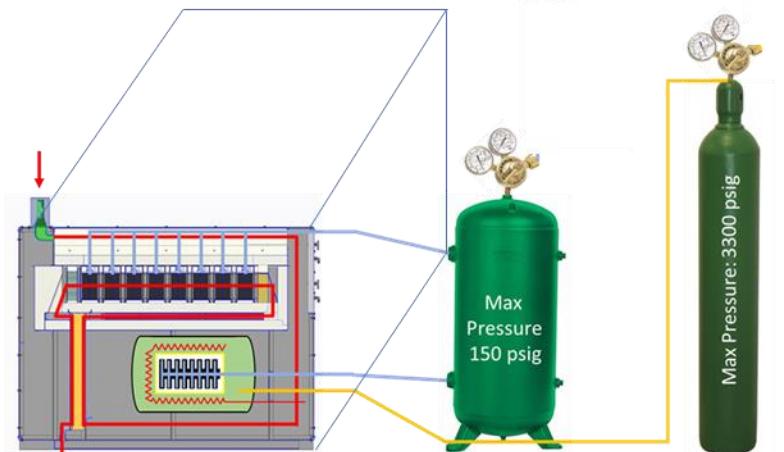
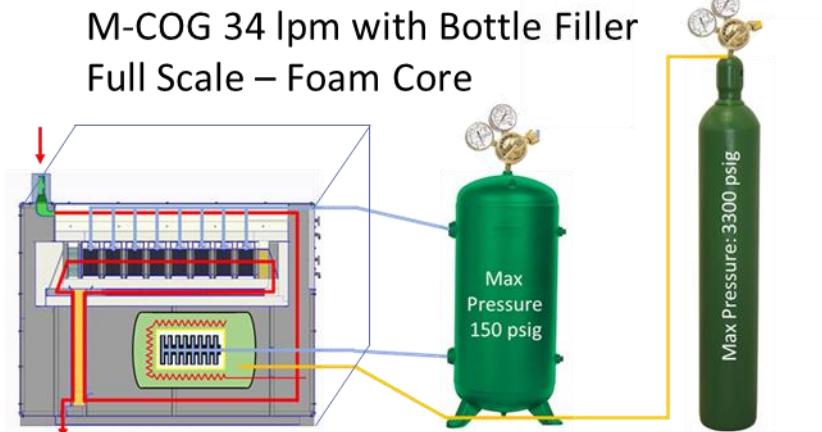
# Near Future: NASA plans to share

- NASA plans to build, then test, then publish test results from Chassis 2
  - Building us underway, system checkouts planned throughout April
  - “Quick Look” testing planned immediately after system checkouts complete
  - “Quick Look” results published as soon as practically possible
- NASA plans to teach and explain
  - Pending RFI responses, NASA is considering a workshop to explain and answer questions
    - Nobody says “Yes” to something they don’t understand
  - Within the constraints of visitor logistics – NASA plans to make the Chassis 2 available for tours

# Items planned for Visitors, Potential Collaborators & Partners



Sample Cylinder  
Purity Report



NASA 3 lpm Spacesuit  
O2 Tank Recharge  
Full Scale – Foam Core

# Near Future: NASA plans to partner

- NASA is searching for partners and collaborators
  - NASA needs a very small, two stage system:
    - The NASA flight system is for re-filling spacesuit oxygen tanks
    - 3 lpm, 200 bar
    - Small scale two-stage cylinder filler test results and field experiences are relevant to the NASA application
- NASA does not have a charter to build systems for hospitals
  - Oxygen systems for global healthcare is outside NASA scope of work
  - NASA intends to make technology available to healthcare scaling partners
  - Partnership arrangements are flexible – interested in novel ideas
- Watch for a NASA Request For Information this summer
  - Current plans are to post RFI to SAM.gov